Introduction and Warnings:

First, let's get the less pleasant stuff out of the way:

1. This amplifier is being offered as a DIY kit, and as such, the end user is entirely responsible for safely building, implementing and using the amplifier.
2. This amplifier does not contain any of the usual safety hooks (OCP, OVP, SCP, over-temp etc.) and it is the responsibility of the end user to ensure the amplifier is operated safely in their setup.
3. I will not be held personally liable for any damage or injury that results from the misuse of this amplifier, or not respecting or accommodating the precautions outlined above. This is being sold as a PCB and some parts. Only you can be responsible for safely using these items.
4. This amplifier is not to be re-sold to anyone, and not to be sold commercially or implemented in any commercial product without my written permission.

This project is not like the headphone amplifier projects, it's significantly more dangerous and requires a much greater degree of skill and knowledge to safely implement. With the headphone amps, we saw all sorts of user errors and issues posted in the forum, some were even kind of funny, but even the worst of them required little more than a small fix and everything was up and running like nothing ever happened. The regulators would current limit, the op-amps had reverse polarity protection, the output buffers had overcurrent and over-temp protection, and the voltages and currents were low enough not to electrocute anyone.

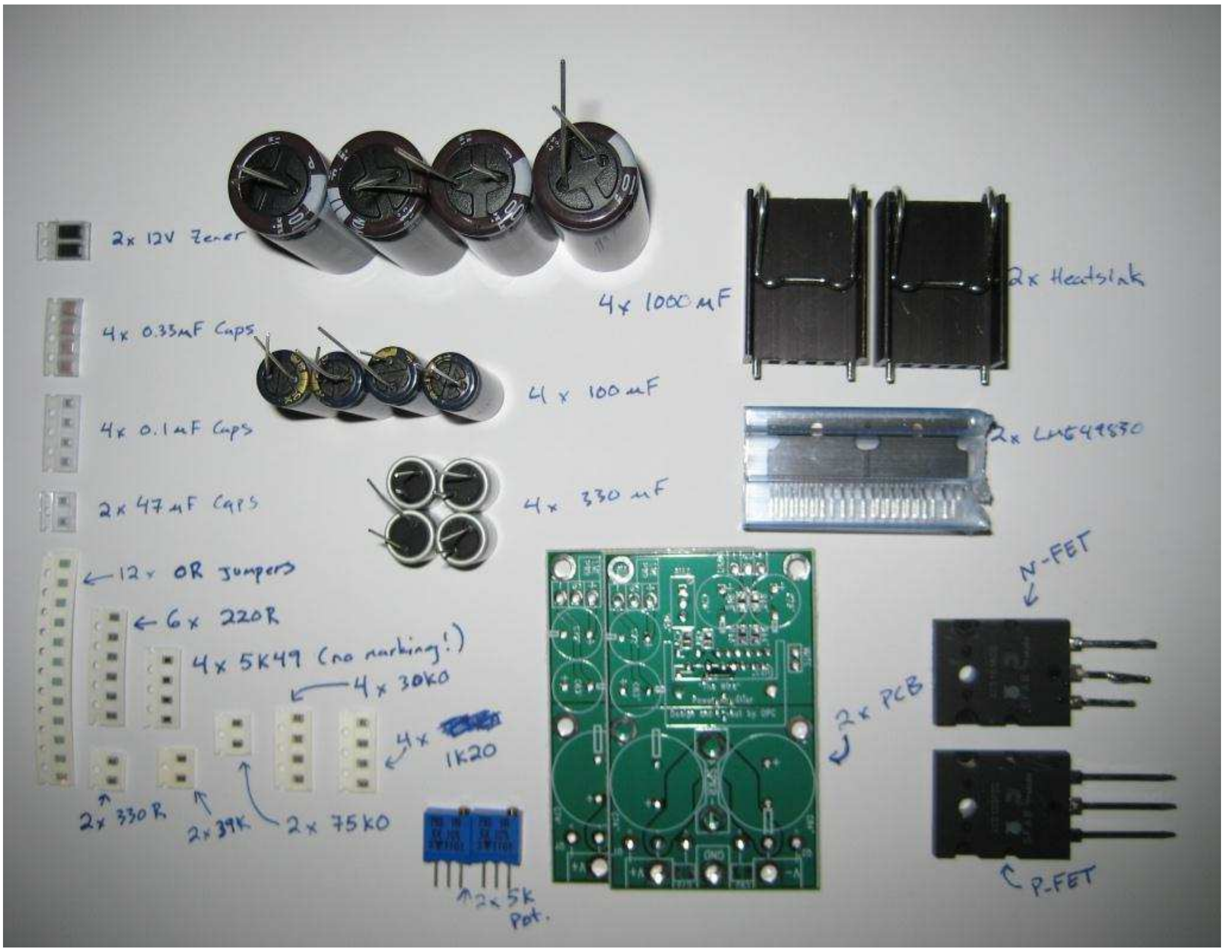
None of those safeguards are in place with this power amp, and I can assure you, if you make mistakes, you will not get a second chance. At these voltages and currents, mosfets and drivers will get destroyed, traces will be blown off of boards, capacitors will explode, and wiring can catch fire. Small parts can become projectiles when they fail, and the end user can be electrocuted by the voltages and currents present in this project.

On a more positive note, if you're cautious, you take your time, you follow the instructions and you double check everything before applying power, all should be fine. The vast majority of people will build this without any problems at all, and they'll be rewarded with an extremely high performance amplifier. There will be a handful of people who rush through the build, omit parts, revers power supply polarities, and short solder joints, but keep in mind that all these mistakes can be easily avoided if you're thorough, cautious and patient.

Alright, enough of the downer-talk… Let's get building!

Get to Know Your Kit:

All kits are packed in pairs, so if you ordered two kits, you will get one bag full of parts. The heatsinks will not be included in the bag, but will instead be packed separately in their own factory bags. The following picture shows everything in the kit laid out.



There are two items missing from this picture; the two 20pF mica caps and the adhesive back thermal interface material for the LME IC's. The two 20pF mica caps will be in either a separate small baggie, or taped in masking tape. Unfortunately Digikey sent them loose in a bag rather than on tape and reel, so I had no choice with these. The thermal interface material will also be in the bag. They are adhesive backed grey pads that need to be cut to size in order to fit behind the LME IC.

Although the capacitors are all self-explanatory, you will need to be able to read the resistor values to identify which is which. For this, I suggest a magnifying glass, using a camera on the macro setting, or just good eyes. It's important to note that the 5k49 resistors have no markings whatsoever, but they are the only unmarked resistors in the kit, and as such, are easy to identify. It is also advantageous to use the number of resistors in each strip to narrow down which is which. As a last resort, the resistors can be removed from their packaging and measured with an ohmmeter to verify their value.

Kit Variations:

Your kit contains more parts than you will need, and that is because it contains enough parts to build a variety of different options. There are also some parts on the board that are intentionally not populated. These parts are called "DNP" in the list, which stands for "do not populate". All possible variations of the kits are outlined below, along with the parts specific to each variant.

Single Ended AC Coupled Input

This version of the amplifier has an AC coupled single ended input using a pair of capacitors and a single 0 ohm resistor to ground the negative input.

REF DES	Value	DK P/N	Description	QTY
R39, R46	5k49	RG20P5.49KBCT-ND	Rf and Rg	2
R43, R44	220R	RG20P220BCT-ND	Rin	2
C76, C78	330uF	493-3718-ND	Input AC Coupling Capacitors	2
R45	0R	MCU0805-0.0-ZZCT-ND	Used to Short the Inverting Input to GND for SE Input	1
R40, R48	DNP	DNP	Bypass the AC Coupling Caps for DC Coupled Input	2

Single Ended DC Coupled Input

This version of the amplifier has a DC coupled single ended input using a pair of 0R resistors to bypass the optional coupling capacitors, and a single 0R resistor to ground the negative input.

REF DES	Value	DK P/N	Description	QTY
R39, R46	5k49	RG20P5.49KBCT-ND	Rf and Rg	2
R43, R44	220R	RG20P220BCT-ND	Rin	2
C76, C78	DNP	DNP	Input AC Coupling Capacitors	2
R45	0R	MCU0805-0.0-ZZCT-ND	Used to Short the Inverting Input to GND for SE Input	1
R40, R48	0R	MCU0805-0.0-ZZCT-ND	Bypass the AC Coupling Caps for DC Coupled Input	2

Balanced AC Coupled Input

This version of the amplifier has an AC coupled differential input using a pair of capacitors.

REF DES	Value	DK P/N	Description	QTY
R39, R46	30k0	RG20P30.0KBCT-ND	Rf and Rg	2
R43, R44	1k20	RG20P1.2KBCT-ND	Rin	2
C76, C78	330uF	493-3718-ND	Input AC Coupling Capacitors	2
R45	DNP	DNP	Used to Short the Inverting Input to GND for SE Input	1
R40, R48	DNP	DNP	Bypass the AC Coupling Caps for DC Coupled Input	2

Balanced DC Coupled Input

This version of the amplifier has a DC coupled differential input using a pair of 0R resistors to bypass the optional coupling capacitors.

REF DES	Value	DK P/N	Description	QTY
R39, R46	30k0	RG20P30.0KBCT-ND	Rf and Rg	2
R43, R44	1k20	RG20P1.2KBCT-ND	Rin	2
C76, C78	DNP	DNP	Input AC Coupling Capacitors	2
R45	DNP	DNP	Used to Short the Inverting Input to GND for SE Input	1
R40, R48	0R	MCU0805-0.0-ZZCT-ND	Bypass the AC Coupling Caps for DC Coupled Input	2

Common Parts for All Variations:

The above lists outline all the parts that are specific or different for each particular variation of the amplifier, but the following list shows all the common parts that should be populated no matter what version you are building.

REF DES	Value	DK P/N	Description	QTY
R54	0R	MCU0805-0.0-ZZCT-ND	Shorts LME GND Plane to Output Stage GND Plane	1
C80	0R	MCU0805-0.0-ZZCT-ND	2-Pole Compensation Capacitor (Not Used - Short)	1
R42	0R	MCU0805-0.0-ZZCT-ND	Used to Set Minimum Bias Point (Not Used - Short)	1
R41	330R	RG20P330BCT-ND	N-Channel Mosfet Gate Resistor	1
R47	220R	RG20P220BCT-ND	P-Channel Mosfet Gate Resistor	1
R38	39k0	311-39.0KCRCT-ND	Mute Circuit - Supply Resistor	1
R53	75k0	311-75.0KCRCT-ND	Mute Circuit - Supply Resistor	1
C75	47uF	587-1779-1-ND	Mute Pin Bypass Capacitor	1
Z1	12V	SMAZ12-TPMSCT-ND	Mute Circuit - 12V Zener to Set Voltage	1
VR5	5k00	T93YA-5.0K-ND	Bias Adjust Potentiometer	1
C79	20pF	338-1101-ND	External Compensation Capacitor (CCOMP)	1
C74 C84	1000uF	493-1988-ND	Mosfet Power Supply Bulk Decoupling	2
C72 C83	100uF	P10775-ND	LME Power Supply Bulk Decoupling	2
C71 C81	0.1uF	445-1418-1-ND	LME Power Supply Local Decoupling	2
C73 C82	0.33uF	445-6097-1-ND	Mosfet Power Supply Local Decoupling	2
R49	DNP	DNP	2-Pole Compensation Resistor (Not Used - Open)	1
C77	DNP	DNP	Bias Circuit Decoupling (Not Used)	1

It is strongly encouraged that all builders stick to these part suggestions unless they are very comfortable with the circuit and fully understand the effects of any changes they may want to implement. Damage and personal injury could result if incorrect parts are mounted.

What Setup is Right for Me?

The answer to that question is entirely dependent on your personal setup, as well as your own tastes and preferences. There is no absolute correct answer to which is best, as it depends heavily on what is used to drive the amp, as well as the particular physical setup of each system.

It is worth noting that the SE input does have a lower overall noise floor under ideal circumstances by about 1-2dB. This can easily be negated in systems where the CMRR of a differential input can be of benefit, as the overall system noise floor will be lower even if the balanced input scheme has slightly worse noise performance under ideal conditions.

It is also worth noting that the balanced setup requires a preceding stage that is comfortable driving a 600 ohm load. All respectable balanced outputs should be happy driving this load, but keep in mind that the input impedance is lower than usual.

Mounting the LME49830 on the heatsink:

The very first thing to do is mount the LME49830 properly on the heatsink. This step requires a completely unpopulated board, so it's best to start here. Mounting the LME can be a bit tricky as the clip is quite strong and requires some effort to get the LME mounted properly. Start by establishing the correct location for the LME on the heatsink. With the heatsink pressed tight against the PCB, and the LME sitting with the leads flush with the bottom of the PCB through-holes, use a pencil to mark the top of the IC on the heatsink. Next, cut the grey thermal interface material (TIM) to size, and stick it in the correct location on the heatsink by aligning it with the line you just drew. Once the TIM is adhered, hold the LME in place with one hand (aligned with the pencil line) and push the clip down until it touches the top of the LME. Pry the clip upward with a flat screwdriver, and slide it onto the surface of the LME. If you did everything correctly, the clip should align perfectly with the centre of the hole in the LME IC. Lastly, check for continuity between the V- pin and the heatsink. If you get an open circuit then you're good to go, if you measure a low impedance or a short, then you will need to start over and do a better job of positioning the TIM.

Populating the Board:

It is best to start with all the SMD parts on the board before soldering any of the larger parts. I like to start on the bottom of the board, soldering all the SMD parts, then flipping the board over, mounting the standoffs, and soldering all the top SMD parts.

Once all the SMD parts are soldered, I like to give the board a thorough cleaning using isopropyl alcohol and an old toothbrush. I soak the board in alcohol, then scrub it thoroughly with the toothbrush until all the flux has been removed. It may take two applications of alcohol to fully remove all the flux. After that, I like to use some "Spray Nine" cleaning solution to give the board a final scrub. A good rinse in water and a thorough dry off finished the job. It's best to use compressed air to get all the water off the board and out of the holes, but a blow dryer will work in a pinch.

Once dry, you can proceed to mount all the through-hole parts on the board. It's a good idea to solder in the + output lead before mounting the heatsink and caps, as it's difficult to get to after the fact.

Once all the parts are mounted, I like to use more isopropyl alcohol applied to a paper towel to clean up all the PTH joints.

The last step is to mount the board and transistors to the heatsink you'll be using, and solder the joints only *after* everything has been mounted. Soldering the joints before-hand runs the risk of not having everything perfectly aligned, and that could put undue stress on the transistor leads. With enough thermal cycling, the leads could eventually break if they are under tension or compression.

<u>The first power-up:</u>

Now for the scary part… it's power time! If you've been working on this all night, and it's now 3:30am, do yourself a favour and just go to bed. Do not attempt to power up the board unless you're awake, aware, not rushed and fully confident in your setup. Like I said before, this is a one-shot deal.

You will absolutely need a minimum of one multimeter to successfully bring up the supply. Don't bother trying without one. Ideally, you want two meters so you can monitor current and voltage simultaneously during power up.

Start by double checking every single connection. Use a multimeter to check for shorts and follow every lead back to the power supply and make sure the polarity is correct. Think about all your grounding, and follow good grounding practice between the PSU and the amp board.

Next, check that you've properly mounted the mosfets to the heatsink. I suggest the use of good (thin) mica insulator and thermal grease, but there are other TIMs out there that are as good or better without the terrible mess. Always check for continuity between the source and the heatsink. If you measure anything other than an open circuit, then something is wrong and you need to double check your mounting. Also be sure to mount the mosfets with the correct torque and bolts. The larger the head of the bolt, the better it will be at spreading the force evenly across the device.

If you have a variac, or even a low voltage supply (say +/-20V) then start with that. Turn the bias potentiometer **FULLY CLOCKWISE TO START.** This sets the bias at a minimum, which is what you want during startup.

Slowly bring up the power supply while monitoring the current to the mosfets and the voltage of the supply. Stop when you get to +/-20V. If all is well, there should be little or no current flowing through the mosfets with the bias pot turned all the way down. If all is well, start turning the bias pot counter-clockwise while monitoring the current. Start with an initial target of 100mA.

At this point it's worth mentioning that you can monitor the current in two ways:

1. Use the current meter function of your multimeter by putting it in series with the +supply lead to the PCB.
2. Solder a 1 ohm precision resistors in series with the + supply and monitor the voltage drop across it. 100mV will mean you have 100mA flowing through the mosfets.

If you can adjust to get 100mV, then you can take a big sigh of relief an pat yourself on the back. Chances are everything is good!

The next step is to ramp up the voltage to your full operating conditions. Before doing this, drop the bias back down to about 50mA. The bias can climb as voltage is increased, and you don't want it to be too high to start. If you have a variac, bring the voltage up slowly while watching for any signs of trouble. If you don't have a variac, then get some safety glasses on and cross your fingers. If everything was good during the low voltage testing, then you should not have any problems here.

Once at full voltage, check the bias current immediately to ensure it's not too high. I would suggest using a bias level of 300-400mA for one pair of dual die mosfets. I found the butter zone to be about 360mA. Above that, you will start to get diminishing returns. If you're running lower voltage rails, feel free to run higher bias. Those with high voltage rails will want to pay careful attention to power dissipation when selecting a bias point. For pure class A operation, I would suggest starting at about 1.25A with +/-25V rails. This will give you about 25 watts of class A output and results in a constant dissipation of 65W per channel. It also sounds very good ☺.

It's a good idea to carefully monitor the operating conditions until the amplifier has had time to fully reach operating temperature. Always double check the bias and rail voltage after the amplifier has reached full temp.

Initial Testing:

It is always best to thoroughly test any amplifier with either a dummy load or a scrap speaker before hooking up to anything too valuable. Sloppy grounding, incorrect parts, solder shorts or sloppy wiring could all cause things like high DC offset or full power oscillation.

Start by measuring both the AC and DC voltage on the output of the amplifier. Both should be 0V with a grounded or floating input. There may be a small DC offset on the output depending on the power supplies and grounding, but it should not exceed about 10mV. If you measure something over 50mV, then something it probably wrong.

If you measure both 0V AC and DC then it's time to hook up your dummy load or scrap speaker. Once it's connected, measure both AC and DC voltage again.

If all is well at this point, it's best to power down and back up again. Watch for transients on the output during power down and power up. With a well behaved power supply, there should not be any start-up or shutdown transients.

Finally, with the unit powered off, connect a source (one you know does not have DC on its output!) and power back up again. Play your favorite track, sit back, and bask in the glory that is your newly completed amplifier!

Always double check all operating characteristics from time to time, and especially when making any changes to wiring, chassis, heatsinks or other layout.

<u>Special Notes and Things to Avoid:</u>

For those who like to tinker, there are a few things to be wary of:

1. The resistor that connects the LME plane to the output stage plane should not be removed. I found that running the LME ground and the output ground separately back to the PSU caused low frequency transients on start-up and shutdown, and sometimes cause the output to have high DC offsets.
2. Large capacitors should not be placed across the bias terminals. If you want to experiment here, try 20pF to start.
3. If you want to implement a mute function, simply short the two pins labelled "MUTE" on the PCB together. This can be implemented with a simple toggle switch.
4. I got better performance by grounding the loudspeaker on the PCB rather than back at the power supply. Your results may differ depending on your supply setup.
5. Exceeding 85V on the LME is strongly discouraged. It will start to run quite hot, and will likely reduce the lifetime of the capacitors that surround it.
6. Exceeding 300W of output starts to get into the "danger zone" for the single pair of mosfets and should not be done unless you really know what you are doing.
7. The metal tabs on the back of the lateral mosfets are actually tied to the source of the mosfets. That means as long as you fully electrically isolate the heatsinks from the chassis or GND, you can mount the mosfets directly to the heatsink with only thermal paste and no insulator. It's worth nothing that in this configuration, the heatsink will swing along with the output, so it you're outputting a 70V peak, then the heatsink will be at 70V as well. If you have internally mounted heatsinks that you can isolate, then significant reductions in thermal resistance can allow for higher dissipation.
8. Don't mess with the compensation values unless you know what you are doing and have the ability to check the effects of your changes. The value selected is good for a very wide power bandwidth at up to 200W. If you plan specifically to run at higher output power (200-300W @ 8Ω) and want additional power bandwidth, then this value can be reduced to 12pF. Always use tight tolerance mica or thin-film capacitors in this location. It's one of the most critical parts in the entire amp. I have had good results with AVX Accu-P Thin Film RF/Microwave caps in this location, and those who like to mess with fancy or obscure parts might want to start here. The 12pF 100V 1% part is suggested (08051K120FBTTR).